REMARKS

Status of the Application

Claims 1, 5-17, and 19-22 are all the claims in the application. Claims 13-15 have been amended for clarity. No new subject matter has been added.

The Office Action

Claims 14 and 15 are recited under 35 U.S.C. § 112, second paragraph.

Claims 1, 5, 9-11, 16, 17, and 19 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim (U.S. Patent No. 6,995,389) in view of Yamada (U.S. Patent No. 6,608,330), Sasaoka (U.S. Patent Application Publication No. 2003/0042496), and Stintz (U.S. Patent Application Publication No. 2002/0114367).

Claims 6-8 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, and Stintz, in view of Hanaoka (U.S. Patent No. 5,804,839).

Claims 12, 13, and 15 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, and Stintz, in view of Morita (U.S. Patent No. 6,121,636).

Claim 14 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Yamada, Sasaoka, and Stintz, in view of Kaneyama (U.S. Patent No. 6,452,214).

Claims 20-22 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, Stintz, and Lester (U.S. Patent No. 6,291,839).

Claim Rejections under 35 U.S.C. § 112, second paragraph

In response to the rejection under 35 U.S.C. § 112, second paragraph, claims 14 and 15 have been amended to depend from claim 12. Claim 13 has been amended to correct an informality. Withdrawal of the foregoing rejection is respectfully requested.

Claim Rejections under 35 U.S.C. § 103

A. Claims 1, 5, 9-11, 16, 17, and 19 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka and Stintz.

The Examiner relies on Kim to teach a gallium nitride compound semiconductor light-emitting device (FIG. 1) comprising a crystalline substrate (10, col. 2, line 55); a light-emitting

layer comprised of a multiple quantum well structure (18, col. 3, lines 3-4) that is formed of at least one gallium nitride compound semiconductor barrier layer doped with an impurity element (13, col. 3, lines 10-12, 16-18, 36-37) and at least one gallium nitride compound semiconductor well layer undoped with any impurity element (14, col. 23, lines 40-47, col. 3, lines 10-18); a contact layer (15, col. 2, lines 61-63); and an Ohmic electrode (16, col. 2, line 64) that is provided on the contact layer and has an aperture through which a portion of the contact layer is exposed, wherein all of the individual gallium nitride compound semiconductor well layers of the multiple quantum well structure each has the same composition (14, col. 3, lines 10-18) and contains a thick portion having a large thickness and a thin portion having a thickness of 1.5 nm or less (col. 3, lines 31-33; each quantum well layer 14 may be regarded to have both a thick portion and a thin portion, each of the same thickness, since neither the relative thickness nor the actual thickness of the thick portion is claimed); the barrier layer is doped with an element at an average atom density of 1×10^{17} cm^{-3} to 5×10^{18} cm^{-3} (13, col. 3, lines 37-40). (*See* Office Action, pages 3-5).

The Examiner acknowledges that Kim does not teach the contact layer formed of a Group III-V compound semiconductor, the Ohmic electrode exhibiting light permeability with respect to light emitted from the light-emitting layer, the barrier layer doped with a Group IV element, and the gallium nitride compound semiconductor well layer being a discontinuous layer including a portion having a thickness of 0 nm. (*See* Office Action, page 5, last paragraph).

The Examiner relies on Yamada to teach a contact layer formed of a Group III-V compound semiconductor for providing an Ohmic electrode (111, col. 8, line 41); an Ohmic electrode (112, FIG. 1) exhibiting light permeability with respect to light emitted from the light-emitting layer (col. 10, line 42), a well layer undoped with any impurity element (108, col. 10, lines 3-4) and being a discontinuous layer (col. 13, lines 20-22). (*See* Office Action, page 6, paragraphs 2-4).

The reason for rejection was that it would have been obvious to modify the device of Kim to make the well layer a discontinuous layer since Yamada discloses it is advantageous to form the well layer a discontinuous layer. (*See* Office Action, page 7, paragraph 2).

The Examiner relies on Stintz to teach a well layer having a portion with a thickness of 0 nm (408, FIG. 11C, layers 406 exists between the layer 408). The Examiner considered that it

would have been obvious to modify the device of Kim in view of Yamada to include into the well layer a portion having a thickness of 0 nm because Yamada discloses the well layer to have portions with a thickness of less than half the average thickness of the layer, a zero thickness is less than half the average thickness, and Stintz discloses that the well layers may be discontinuous having regions of the layer with zero thickness. (*See* Office Action, page 8, paragraphs 1 and 2).

The Examiner's rejection is respectfully traversed.

A. Claim 1 recites "a light-emitting layer is comprised of a multiple quantum well structure that is formed of a barrier layer and a well layer, wherein each and all of the individual gallium nitride compound semiconductor well layers of the multiple quantum well structure have the same composition."

Kim describes the active region 18 having quantum well layers 14, barrier layers 13, and reservoir layers 12. (Col. 3, lines 3-4). Reservoir layers 12 have a larger band gap than quantum wells 14, and a smaller band gap than barrier layers 13. Quantum well layers and reservoir layers are InGaN and barrier layers are AlGaInN. As the amount of indium in an InGaN layer decreases, the bandgap increases, thus **reservoir layers 12 contain less indium than quantum well layers 14**. (Col. 3, lines 3-25).

Therefore, the light-emitting layer of Kim comprises the quantum well structure which includes all of the layers 12, 13, and 14. **The reservoir layers 12 and well layers 14 differ in In composition.** Kim clearly teaches that reservoir layers must have a lower In concentration than the well layers, to hold carriers with a long decay time. (Col. 3, lines 49-53).

Accordingly, Kim does not teach a light-emitting layer which is comprised of a multiple quantum well structure formed of a barrier layer and a well layer, wherein each and all of the individual gallium nitride compound semiconductor well layers of the multiple quantum well structure have the same composition, as claimed.

B. Claim 1 recites "well layers of the multiple quantum well structure each … contains a thick portion having a large thickness and a thin portion having a thickness of 1.5 nm or less."

In the portions cited by the Examiner, Kim describes that the barrier layers 13 have a thickness between 5 and 200 angstroms, and often have a thickness of 20 angstroms or less.

Quantum well layers 14 have a thickness between 5 and 100 angstroms and often have a thickness of 25 angstroms. (Col. 3, lines 28-33).

Accordingly, Kim discloses that the barrier layers have a thickness of 20 angstroms or less. However, Kim teaches that the quantum well layers 14 have a thickness between 5 and 100 angstroms. (Col. 3, lines 28-33). Thus, contrary to the Examiner's assertion, Kim does not describe that the well layers have a thickness less than 1.5 nm, as claimed.

Further, Kim's disclosure of a thickness between 5 and 100 angstroms does not disclose that the well layer 14 has a thick portion and a thin portion, as claimed.

C. Claim 1 recites "a barrier layer which is doped with a Group IV element at an average atom density of 1 x 10^{17} cm^{-3} to 5 x 10^{18} cm^{-3} for the purpose of decreasing the forward voltage of the device."

In the portions cited by the Examiner, Kim discloses a dopant concentration of the reservoir layer between 5 x 10^{16} cm^{-3} and 5 x 10^{19} cm^{-3}. (Col. 3, lines 38-40). However, Kim does not teach that the barrier layer is doped at a density of between 5 x 10^{16} cm^{-3} and 5 x 10^{19} cm^{-3}, as claimed.

D. Non-Obviousness of the Combination

The Examiner asserts that it would have been obvious to modify the device of Kim to make the well layer a discontinuous layer since Yamada discloses it is advantageous to form the well layer a discontinuous layer. (*See* Office Action, page 7, paragraph 2).

Initially, Yamada does not disclose that it is advantageous to form the well layer as a discontinuous layer.

Further, Yamada discloses that the light emitting efficiency of a light emitting device becomes higher as flatness or crystallinity of the growing side of the well layer become better. (Col. 4, lines 16-20).

However, when an interaction works between the 1st well layer and the 2nd well layer, and when the 1st and 2nd well layers emit light of different wavelengths, Yamada explains that some asperity of the well layers affects the desirable light emitting efficiency. The well layer 14 of Kim has a homogeneous composition so that each well layer emits a light of the same wavelength as is also pointed out by the Examiner. Therefore, if the well layer of Yamada is

applied to the device of Kim, as proposed by the Examiner, it is apparent to those skilled in the art that the light emitting efficiency will be negatively affected.

Additionally, Kim describes the reservoir layer 12, to improve the light emitting efficiency.

Therefore, there is no reason for one skilled in the art to incorporate the well layer of Yamada into the device of Kim, to improve the light emitting efficiency.

Sasaoka and Stintz do not cure any above-discussed deficiency of Kim and/ or Yamada.

Accordingly, Applicants respectfully submit that the Examiner's proposed combination does not teach or suggest at least: "a light-emitting layer (15) comprised of a multiple quantum well structure that is formed of … barrier layer … and … well layer, … all of the individual gallium nitride compound semiconductor well layers of the multiple quantum well structure each has the same composition and contains a thick portion having a large thickness and a thin portion having a thickness of 1.5 nm or less; … a barrier layer … is doped with a Group IV element at an average atom density of 1×10^{17} cm^{-3} to 5×10^{18} cm^{-3}," and also there is no suggestion, under the *KSR* guidelines to make the Examiner's proposed combination.

It is, therefore, respectfully submitted that **claim 1 and dependent claims 5, 9-11, 16, 17, and 19** are patentable.

B. **Claims 6-8** stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, Stintz, and Hanaoka.

Claims 12, 13, and 15 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, Stintz, and Morita.

Claim 14 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, Stintz, and Kaneyama.

Claims 20-22 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kim, Yamada, Sasaoka, Stintz, and Lester.

Claims 6-8, 12-15, and 20-22 depend on claim 1. As discussed above, Kim, Yamada, Sasaoka, and Stintz do not teach all of the features of claim 1. Neither Hanaoka, Morita, Kaneyama, nor Lester cures any above-discussed deficiency of these references. It is, therefore,

respectfully submitted that **claims 6-8, 12-15, and 20-22** are patentable at least by virtue of their dependencies.

CONCLUSION

Withdrawal of all rejections and allowance of claims 1, 5-17, and 19-22 are earnestly solicited. In the event that the Examiner believes that it may be helpful to advance the prosecution of this application, the Examiner is invited to contact the undersigned at the local Washington, D.C. telephone number indicated below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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